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Radio Transceiver

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The invention relates to a radio transceiver, in particular mobile telephone, as claimed in the preamble of claim 1.

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In the mobile telephones which are operated according to the GSM standard, the standard does not permit a permanent simultaneous transmission and reception mode. These devices can therefore be operated with a common transmission and reception antenna without the serious risk of the receiver input being overloaded by the transmission signal.

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The situation with mobile phones which are embodimented according to the future UMTS standard is different. In such devices having what is referred to as the full duplex mode, a chronological overlap between transmission mode and reception mode is permitted and also occurs during operation. Therefore, in these devices - as is generally also the case with the radio transceivers with chronological overlaps between transmission mode and reception mode - an efficient decoupling is necessary between the transmitter and receiver in order to avoid overloading or even destruction of the receiver input by the high power of the transmission signal.

This problem is achieved according to the prior art by what is referred to as a duplex filter or a duplexer. This basically comprises two high-quality bandpass filters with steep edges. At the transmission end, a transmission filter is used to suppress the transmitter noise and possible sideband emissions. At the receiver end, a reception filter ensures very high receiver

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selectivity. Alternatively, the aforementioned duplexer can also be embodied as a band-stop duplexer in which the transmission filter is a band stop with a zero position in the reception band, and the reception filter is a band stop with a zero position in the transmission band.

The aforementioned filter embodiments are virtually impossible to integrate owing to their specific properties and are thus not compatible with the trend for ever smaller and more lightweight mobile phones. In addition, they are costly and also problematic in terms of the ongoing reduction of costs in this field.

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The invention is therefore based on the object of making available a radio transceiver with improved transmitter/receiver decoupling, which in particular requires less space and less expenditure for this function.

This object is achieved by means of a radio transceiver having the features of claim 1.

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The invention includes the essential idea of largely bringing about the necessary transmitter/receiver decoupling in a radio transceiver which operates with frequency-division multiplexing by compensating the transmission signal element present at the receiver input. This makes it possible to dispense with transmission and reception filters which have steep edges and cannot be constructed using integrated semiconductor technology, and this ultimately makes possible an integrated, and thus space-saving and cost-effective embodiment of the decoupling means.

The compensation element is in particular connected in parallel with a transmission band-transmitting filter and with a reception band-transmitting filter - neither

of which need to satisfy any extreme requirements owing to the provision of the compensation element - and is connected to the input of a reception pre-amplifier or reception mixer of the receiver part.

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The compensation element comprises, in particular, means for separately setting the phase and amplitude of the signal to be processed so that it makes available an output signal which is suitable in terms of phase and amplitude for extinguishing crosstalk from a transmission signal element.

It can to this extent be permanently tuned - specifically either to a frequency or a channel or to a plurality of frequencies or channels, each channel then being assigned a set of tuning parameters and switching over between the tuning parameter sets also being performed when there is a channel change. Tuning parameters are to be understood here as a phase rotation angle and an amplitude value. This embodiment, which can also be characterized as "static" and has permanently set parameters, can be implemented in a particularly simple and cost-effective way.

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However, embodimenting the compensation element with adaptive control can be adapted more flexibly to different conditions of use and is therefore preferred in practice from the current viewpoint. With this embodiment, it is also possible to compensate changes in the antenna adaptation, which can occur, for example, as a result of contact or close proximity of the antenna to conductive objects or to the body. The adaptive control is based on a voltage measurement at the receiver input, phase and amplitude being changed in the compensation element in such a way that this measured voltage is minimized. The means which are required for adaptively controlling the compensation element can be collectively described by the term

"compensation control element". In addition to the measuring device - which can overall also be embodied as a power measuring device - this compensation control element comprises, in one preferred embodiment, means for the IF conversion of the input signal to a separate intermediate frequency (using the pre-amplifier and mixer which are contained in any case in the receiver part), a simple bandpass filter connected downstream and a simple AM receiver part connected downstream of the latter.

Its output signal then represents the input variable of the adaptive control. The aforementioned bandpass filter is advantageously tuned to the reception frequency in narrowband fashion in order to achieve a high level of sensitivity of the control.

In one space-saving and cost-effective embodiment, the compensation element is integrated into the RF components of the transceiver, specifically in particular in the form of a highly integrated circuit (LSI or VLSI) using silicon technology.

The advantages and embodiments of the invention also emerge from the subclaims and from the following description of preferred exemplary embodiments with reference to the figures, of which:

Fig. 1 shows a schematic view of a first embodiment of the invention in the form of a functional block circuit diagram,

Fig. 2 shows a schematic view explaining the control of the compensation element from fig. 1

Fig. 3 shows a schematic view of a second embodiment of the invention in the form of a functional block circuit diagram,

Fig. 4 shows a schematic view a third embodiment of the invention in the form of a functional block circuit diagram, and Fig. 5 shows a schematic view of a fourth embodiment of the invention in the form of a functional block circuit diagram.

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The components of a mobile phone 1 which are essential in the context of the embodiment of the invention and their interaction are shown in sketch form in Fig.1. A transmitter output stage 3, which receives a transmission signal at the input end, is connected at the output end via a transmission band-transmitting filter 5 to a feedpoint 7a of a combined transmission/reception antenna 7. A reception band-transmitting filter 11 is connected between the feedpoint 7a of the antenna 7 and the input of a reception pre-amplifier 9, at whose output a pre-amplified reception signal is made available. The transmission curves of the transmission band-transmitting filter 5 and of the reception band-transmitting filter 11 have a frequency spacing from one another which is predetermined by the standard of the mobile phone system; according to the GSM standard (which, however, also provides for time-division duplex between the reception and transmission mode), this spacing is, for example, 45 MHz. The two transmitting filters 5, 11 form together a duplex filter, of which, however, less is demanded in terms of the edge steepness of the filter characteristic curves with the proposed solution than is demanded with a conventional mobile phone duplex filter, and which can therefore be implemented using integrated silicon technology.

This is made possible by providing a compensation element 13 between the output of the transmitter output stage 3 and the input of the reception pre-amplifier 9.

The arrow "control of the compensation element" which points to the compensation element 13 in Fig. 1 indicates in a general sense that the compensation element 13 normally does not have any permanently set, invariable compensation characteristics but can instead be controlled as a function of the predetermined input variables – for example a frequency assignment or channel assignment and/or a measurement variable detected in the arrangement (see below for details).

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Fig. 1 shows that the compensation element 13 according to Fig. 1 has, in a preferred embodiment, a phase compensation element 13.1 and an amplitude compensation element 13.2 which is connected in series with the latter, both compensation elements 13.1, 13.2 each receiving a specific control signal "control of the phase response" or "control of the gain or attenuation" and their transmission characteristics being set by the respective control signal.

Fig. 3 is a further illustration of the mobile phone 1, according to Fig. 1, a compensation control element 15, which receives a supplementary information item for the transmission/reception mode as input signal and which has the purpose of controlling the compensation element 13, is also illustrated. The compensation control unit 15 can have a memory which is structured in the manner of a lookup table and in which assignments between predetermined transmission/reception frequencies or channels and suitable phase angle/amplitude response value pairs of the compensation element 13 are stored. If the mobile phone has only one possible frequency constellation or channel constellation for the transmission/reception mode, just a single pair of values is correspondingly provided. In addition, in one particularly flexible embodiment, the compensation control unit 15 can additionally process information which characterizes the state of the system at a given

time; see below.

Fig. 4 shows a mobile phone 1′ which is modified in comparison with Fig. 1 and in which the control unit receives and processes a supplementary information item which is tapped at the input of the reception amplifier 9. A measuring amplifier 17 and a rectifier unit 19, in which devices an additional input signal, representing the voltage present at the input of the reception pre-amplifier 9, for the compensation control unit 15 is acquired, are connected downstream of a tap point 9a. The control unit 15 is configured here in such a way that this voltage is minimized by suitably setting the phase and amplitude (on the basis of a value pair which is predetermined as a function of the frequency, as explained above).

Fig. 5 shows an embodiment of a mobile phone 1′′ which is modified in comparison with Fig. 4 and which, in addition to the components shown in Fig. 3 (which are provided with the same reference numerals and are not described once more here) has a simple "second receiver" 21 at the output end of the reception pre-amplifier. Said "second receiver" 21 is connected to a control input of a modified compensation control unit 15′′.

The amplitude of the input signal is detected in narrowband fashion with the second receiver 21, after which even very small values of crosstalk power can be detected and compensated. The second receiver 21 comprises a mixer 21.1 in which an intermediate frequency conversion of the reception signal present at the reception pre-amplifier 9 to a frequency f(vco) is performed, a bandpass filter 21.2, connected downstream of the latter, for carrying out simple filtering at the intermediate frequency f(iftx) and an AM receiver 21.3/21.4 which is connected downstream of the bandpass

filter 21.2. In the reception signal path, a further, simple bandpass filter 23 for filtering at a second intermediate frequency f(ifrx) is connected downstream of the mixer 21.1.

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The proposed embodiment can be implemented in integrated fashion using silicon technology, which is advantageous technologically and in terms of costs and service value. In the embodiment shown in Fig. 5, the mixer 21.1 and the pre-amplifier 21.3 of the AM receiver can be implemented with a mixer and pre-amplifier which are present in any case in the receiver part, so that in this respect there is no need for additional hardware expenditure.

The embodiment of the invention is not restricted to the examples explained above but is rather also possible in refinements whose development lies within the scope of activity by a person skilled in the art.